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DISSECTION ON THE COMPRESSIVE STRENGTH OF CONCRETE BY REPLACING SAND WITH LATERITE SOIL AND M-SAND

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ABSTRACT

Utilization of concrete in most of the civil engineering applications has led to a high demand on the ingredients of concrete. Sand is a demanded ingredient of concrete which is costly due to its lack of availability. The lack of constituents have triggered different searches and investigations for replacing sand with Laterite soil as fine aggregate. This study investigates the suitability of using a mix of Laterite soil and M- sand as the fine aggregate in place of standard seeks to determine whether laterized concrete would satisfy the minimum compressive strength for use in reinforced concrete works. Ordinary Portland cement was used as the binder. Batching was by weight Laterite soil and M- sand was used as the fine aggregate and granite of 20 mm nominal size was used as the coarse aggregate. A total of 12 standard 150 mm size concrete cubes and 4 concrete cylinders of diameter 150mm were casted and cured for 7, 14, 28 days , then weighed and crushed. The average compressive strength of laterized concrete was found to be 29.05 N/mm^{2}a value lower than the average value of 40 N/mm^2. The compressive strength obtained by concrete replacing ordinary sand with 50% laterite soil and 50% M- sand at 28 days is 47.08 N/mm^2. Therefore laterized concrete could be used as a fine aggregate for making structural concrete in places having problematic soil with poor bearing capacity as the soil should not have to hold larger loads.

Key words: compressive strength, laterized concrete, Laterite, traditional concrete, structural concrete.

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1. INTRODUCTION

Concrete is the most popular building material in the world. Utilization of this material in different structures have placed a high demand for its constituent materials. In India river sand has been used as one of the major components of concrete since it is easily available and its well graded nature. River sand is mainly used for all kinds of civil engineering constructions. The excessive excavation of river sand is becoming a serious environmental issue. Hence it is necessary to explore possible alternative solution to minimize the use of river sand. Due to the continuous use of aggregate, river sand is facing a great scarcity and the production of concrete is degrading the environment. This constant extraction of river sand from the river bed for the construction purpose affects the storage capacity of the river and leads to severe water scarcity during lean seasons. This affects the living organisms in the river as well. So it is necessary to develop alternative materials for replacing natural river sand in concrete. One of the potential marginal materials suitable for replacing sand in concrete is Laterite soil. Laterite is a product of intense sub aerial weathering. In India, Laterite soil occupy an area about 1,30,066 sq.km and is well developed on the summits of Deccan hills, Karnataka, Kerala, the Eastern Ghats, west Maharashtra and the central parts of Odisha and Assam. The Laterite terrain of Kerala occupies the central region of state and covers about 60% of the state. Laterite has been utilized in building construction for many years ago and till date a few proportions of the world population still lives in Laterite structures. The utilization of these abundantly locally available materials to replace the normal aggregate in the production of concrete has been proved as the best and alternative solution in the economic aspect especially in developing countries like India.

In the paper [1] it is suggested that laterite soil can be used as fine aggregate for making structural concrete. Laterized concrete would be especially used for concrete elements under mild conditions exposure that are reasonably protected from the effects of harsh weather. Also since laterized concrete has lower unit weight than traditional concrete, it is more suitable for the places with problematic soil that have poor or unreliable bearing capacities. Hence the primary objective of this experimental work is to study the behavior of partially replaced laterized concrete by using Laterite soil – m sand mixture and to optimize percentage of replacement.

The project also aims in reducing the over exploitation of the river sand which is currently used as the fine aggregate in most of the concrete mixes thereby making a sustainable, economic and eco-friendly development.

2. MATERIALS AND TESTING

Ordinary Portland cement confirming to IS 12269 – 1987 was used as the binding material. Potable water obtained from the nearby area was used for this work. Laterite soil obtained from a burrow pit in the northern part of Palakkad district, Kerala and M- sand was used as fine aggregate. The material had low silt and clay content and was free from foreign substances.

2.1. Cement

The cement used is Ordinary Portland Cement confirming to Indian Standards IS 12269 – 1987 of grade 53.The tests conducted on cement are standard consistency, initial setting time, final setting time, and specific gravity.

2.1.1. Standard Consistency Test

The apparatus used for testing standard consistency is the Vicat Apparatus. 300g of cement is taken for the test. The results are shown in Table 1.

Table 1 Determination of Standard Consistency of Cement

Standard consistency of cement (P) = 32%

Weight Of Sample (G)	Percentage Of Water Added (%)	Quantity Of Water Taken (Ml)	Depth Of Penetration Of Plunger (Mm)	
			FROM TOP	FROM BOTTOM
300	28	84	32	18
300	30	90	38	12
300	32	96	44	6

2.1.2. Initial Setting Time

A paste of 300g of cement with 0.85 times the water required to give a paste of standard consistency is prepared. The paste shall be gauged in the manner and under the conditions prescribed in IS 4031 (Part 4) – 1988. The test results are shown in Table 2.

Table 2 Determination of Initial Setting Time of Cement

Initial setting time of cement = 30 minutes

Time from the Instant of Water Added in Min	Depth of Penetration from Top of Mould(Mm)
1	45
10	44
20	44
25	43
30	43

2.1.3. Final Setting Time

A paste of 300g cement with 0.85 times the water required to give a paste of standard consistency is prepared. The paste shall be gauged in the manner and under the conditions prescribed in IS 4031 (part 4) – 1988. 96 ml of water is added to make the paste. The final setting time of cement is found to be 480 minutes.

2.1.4. Specific Gravity

The cement is filled up to 1/3 of the pycnometer, which is the apparatus used for testing the specific gravity of fine aggregate. This is weighed and noted the weight as A. The pycnometer is again filled with cement up to 1/3 and the remaining is filled with water. This weight as noted as B. The cement is removed from the pycnometer and is completely filled with water, this is weighed and the weight is noted as C. Then the weight of empty pycnometer is taken and noted the weight as D. The test results are as follows

Weight of specific gravity bottle with cement A = 210g
Weight of specific gravity bottle with cement and kerosene B = 396g
Weight of specific gravity bottle with kerosene C = 355g
Weight of empty specific gravity bottle D = 150 g
Specific gravity = (A-D)/(A-D)-(B-C)

= (210-150)/(210-150)-(396-355)

The specific gravity of cement is found to be 3.15

2.2. Fine Aggregate

The fine aggregates used are Ordinary river sand, Laterite soil and M- sand confirming to IS 383 – 1970. The tests conducted on fine aggregate are specific gravity test and particle size distribution test. The test results for different category of fine aggregate used in this project are as follows.

2.3. Ordinary River Sand

Ordinary river sand confirming to IS 383 – 1970 is collected from the nearby areas of Coimbatore.

2.3.1. Specific Gravity Test

The sand is filled up to 1/3 of the pycnometer, which is the apparatus used for testing the specific gravity of fine aggregate. This is weighed and noted the weight as A. The pycnometer is again filled with sand up to 1/3 and the remaining is filled with water. This weight as noted as B. The sand is removed from the pycnometer and is completely filled with water, this is weighed and the weight is noted as C. Then the weight of empty pycnometer is taken and noted the weight as D. The test results are as follows.

Weight of pycnometer with sand A = 1170g

Weight of pycnometer with sand and water B = 1810g

Weight of pycnometer with water C = 1510g

Weight of empty pycnometer D = 665g

Specific gravity = (A-D)/(A-D)-(B-C)

= (1170- 665)/(1170- 665)- (1810- 1510)

The specific gravity of ordinary river sand is found to be 2.46.

2.3.2. Particle Size Distribution

IS Sieve designations of 10mm, 4.75mm, 2.63mm, 1.18mm, 600µ, 300µ, 150µ are used for testing the particle size distribution. The sieves are arranged according to the correct order and 1000g of sand is allowed for sieving. On completion of sieving the materials retained on each sieve together with any material cleaned from the mesh is weighed. The sieve analysis result for ordinary river sand is given in table 4. The grading curve is shown in Figure 1.

Table 3 Result of sieve analysis for ordinary river sand

Fineness modulus = 4.04

S No	IS Sieve	Weight of Particle Retained (G)	% Weight Retained	Cumulative %of Weight Retained	%Passing
1	4.75mm	55	5.5	5.5	94.5
2	2.36mm	75	7.5	13	87
3	1.18mm	260	26	39	61
4	600µ	215	21.5	60.5	39.5
5	300µ	280	28	88.5	11.5
6	150µ	95	9.5	98	2
7	pan	20	2.0	100	0

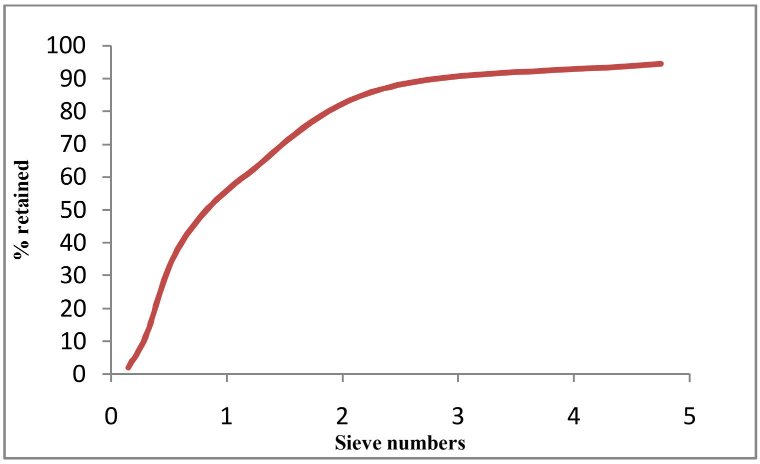

Figure 1 Grading curve for Ordinary river sand

2.4. Laterite Soil

The laterite soil confirming to IS 383 -1970 is collected from the northern region of Palakkad district, kerala.

2.4.1. Specific Gravity Test

The result for the specific gravity test conducted on Laterite soil is as follows.

Weight of pycnometer with laterite soil	A= 1070g
Weight of pycnometer with laterite soil and water	B= 1740g
Weight of pycnometer with water	C= 1520g
Weight of empty pycnometer	D = 670g

Specific gravity = (A-D)/(A-D)-(B-C)

= (1070-670)/(1070-670)-(1740-1520)

The specific gravity for laterite soil is found to be 2.2

2.4.2. Particle Size Distribution

The results for the sieve analysis – particle size distribution test conducted on laterite soil is as shown in Table 4. The grading curve for the result is shown in Figure 2.

Table 4 Result of sieve analysis for laterite soil

Fineness modulus = 3.73

S No	IS Sieve	Weight of Particle Retained (G)	% Weight Retained	Cumulative % of Weight Retained	% Passing
1	4.75mm	10	1	0	0
2	2.36mm	185	18.5	19.5	80.5
3	1.18mm	210	21	40.5	59.5
4	600µ	115	11.5	52	48
5	300µ	210	21	73	27
6	150µ	155	15.5	88.5	11.5
7	pan	115	11.5	100	0

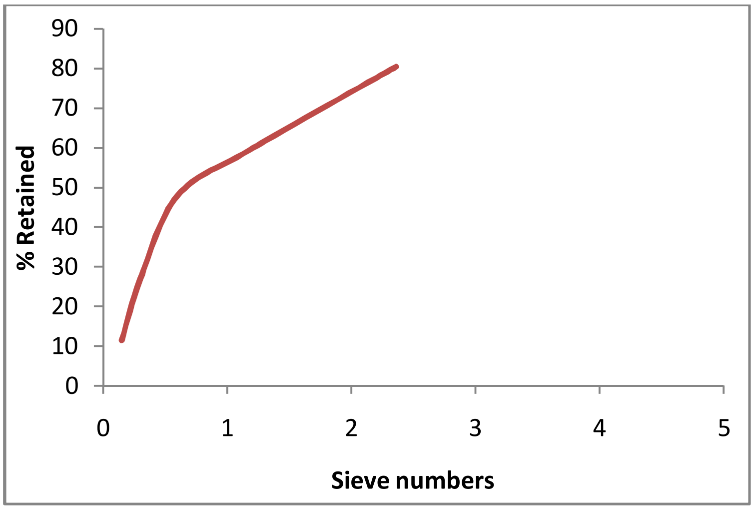

Figure 2 grading curve for laterite soil

2.5. M-Sand

M-Sand elaborated as Manufactured sand confirming to IS383-1970 is collected from the near by areas of Coimbatore.

2.5.1. Specific Gravity Test

The results for the specific gravity test conducted on M-Sand are as follows.

Weight of pycnometer with M- sand	A= 1275g
Weight of pycnometer with M-sand and water	B = 1910g
Weight of pycnometer with water	C = 1550g
Weight of empty pycnometer	D = 660g

Specific Gravity = (A-D)/(A-D)-(B-C)

= (1275-660)/(1275-660)-(1910-1550)

The specific gravity of M- sand is found to be 2.4

2.5.2. Particle size Distribution

The results for the sieve analysis – particle size distribution test conducted on laterite soil is as shown in table 6. The grading curve for the result is shown in figure 3.

Table 5 Result of sieve analysis for laterite soil

Fineness modulus = 3.23

S No	IS Sieve	Weight of Particle Retained (G)	% Weight Retained	Cumulative % of Weight Retained	% Passing
1	4.75mm	0	0	0	100
2	2.36mm	100	1	1	99
3	1.18mm	240	24	25	75
4	600µ	180	18	43	55
5	300µ	230	23	66	34
6	150µ	220	22	88	12
7	pan	120	12	100	0

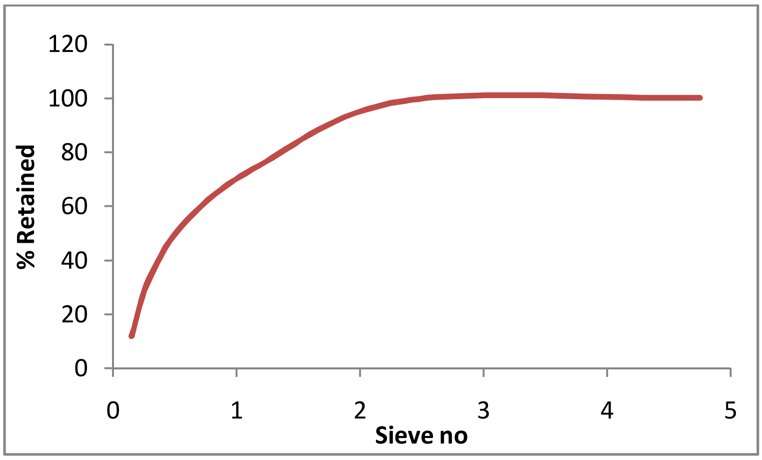

Figure 3 Grading curve for M- sand.

2.6. Coarse Aggregate

Granite of 20mm nominal size confirming to IS 383-1970 is collected from the nearby areas of Coimbatore. The tests conducted on coarse aggregate are specific gravity test and particle size distribution test. The results for the tests are as follows.

2.6.1. Specific Gravity Test

The results for the specific gravity test conducted on coarse aggregate are as follows.

Weight of pycnometer with coarse aggregate	A= 1170g
Weight of pycnometer with coarse aggregate and water	B = 1845g
Weight of pycnometer with water	C = 1510g
Weight of empty pycnometer	D = 665g

Specific gravity = (A-D)/(A-D)-(B-C)

= (1170-665)/(1170-665)-(1845-1510)

The specific gravity of coarse aggregate is found to be 2.97.

2.6.2. Particle Size Distribution

The IS sieve designations used for testing the particle size distribution of coarse aggregate are 63mm, 40mm, 20mm, 16mm, 12.5mm, 10mm, 6.3mm and 4.75mm. The sieves are arranged in order and weighted coarse aggregate is allowed to sieve. The results for the sieve analysis – particle size distribution test conducted on coarse aggregate is as shown in table 7.

Table 6 Result of sieve analysis for coarse aggregate

Fineness modulus = 5.46

S.No	IS Sieve	Weight of Material Retained (Kg)	% Weight Retained	Cumulative %of Weight Retained	%Finer
1	63mm	0	0	0	0
2	40mm	0	0	0	0
3	20mm	0.09	3	3	97
4	16mm	1.56	52	55	45
5	12.5mm	1.10	36.67	91.67	8.33
6	10mm	0.195	6.5	98.17	1.83
7	6.3mm	0.025	0.83	99	1
8	4.75mm	0.010	0.333	99.333	0.667
9	Pan	0.02	0.66	99.993	0.007

3. MIX DESIGN

The mix designs for the concrete replacing sand with laterite soil and M- sand has been calculated using the code for concrete mix design proportioning IS 10262- 2009. The target mean strength is set to be 40 N/mm^2. The mix ratios used for this work is given in table 7.

Table 7 Mix ratios for different mixes

Description		**C**	**FA**	**CA**	**W**
Traditional concrete	Kg/cube	6.04	8.64	16.88	2.7
	Ratio	1	1.43	2.79	0.44
Fully laterized concrete	Kg/cube	6.044	7.65	16.88	2.7
	Ratio	1	1.26	2.79	0.44
Concrete replacing sand with M- sand	Kg/cube	6.04	8.35	16.88	2.7
	Ratio	1	1.38	2.79	0.44
Concrete replacing sand with 50% laterite soil & 50% M- sand	Kg/cube	6.04	8.004	16.887	2.7
	Ratio	1	1.32	2.79	0.44

4. FRESH CONCRETE PROPERTY TEST

The tests that can be conducted on fresh concrete are slump cone test, compaction factor test etc. in this work slump cone test as per IS 1199-1959 is tested for each mixes of concrete. Concrete according to each mixes are made and in filled in the mould, which is placed on a horizontal non porous base plate. The observations for slump cone test conducted on the fresh concrete for each mixes are given below. The result is tabulated in table 9.

4.1. Traditional Concrete

Initial height of cone = 30 cm = 300mm

Height of cone after subside= 18.5 cm = 185 mm

Slump value = 300-185

= 115mm

Therefore the slump is shear slump.

4.2. Fully Laterized Concrete

Initial height of slump = 30 cm = 300mm

Height of slump after subside = 28.5 cm = 285 mm

Slump value = 300-285

= 15mm

Therefore the slump is true slump.

4.3. Concrete replacing Sand with 50% Laterite Soil and 50% M- Sand

Initial height of the slump = 30 cm = 300mm
Height of slump after subside = 27.5 cm = 275 mm
Slump value = 300-275
= 25mm

Therefore the slump is true slump.

4.4. Concrete Replacing Sand with M- Sand

Initial height of slump = 30 cm = 300mm
Height of slump after subside = 28cm = 280mm
Slump value = 300-280
= 20mm

Therefore the slump is true slump.

Table 9 Result for slump cone test for fresh concrete.

Description	Slump value
Traditional concrete	115mm
Fully laterized concrete	15mm
Concrete replacing sand with 50% laterite soil & 50% M- sand	25mm
Concrete replacing sand with M- sand	20mm

5. HARDENED CONCRETE PROPERTY TEST

Cubes and cylinders with different mix proportions are casted and are cured for 7, 14 and 28 days. The specimen is removed from water after the specified curing time and excess water from the surface of the specimen is wiped off. The dimension of the specimen is taken to the nearest 0.2m. The specimen is placed tight in the machine in such a manner that the load shall be applied to the opposite side of the cube cast. The load is applied gradually without shock and continuously at the rate of 140 kg/ cm^2/minute till the specimen fails. The results for compressive strength test conducted on concrete for different mixes are as shown in table 10. Strength comparison for 7 days and 28 days compressive strength test on cubes with different mixes are shown in figure 4 and figure 5 respectively. Strength comparison between 7 days and 28 days compressive strength test on cylinders with different mixes are shown in figure 6.

Table 10 Result for compressive strength test conducted on concrete

Description	7 days	14 days	28 days
Normal mix cube	34.04	38.4	47.11
cylinder	14.14		
Fully laterized concrete cube	20.71	23.33	28.58
cylinder	15.70		
Concrete replacing ordinary sand with M- sand			

Cube	36.58	40.23	47.55
cylinder	14.48		
Concrete replacing ordinary sand with 50% laterite soil & 50 % M- sand Cube	29.87	34.60	44.08
cylinder	12.44		

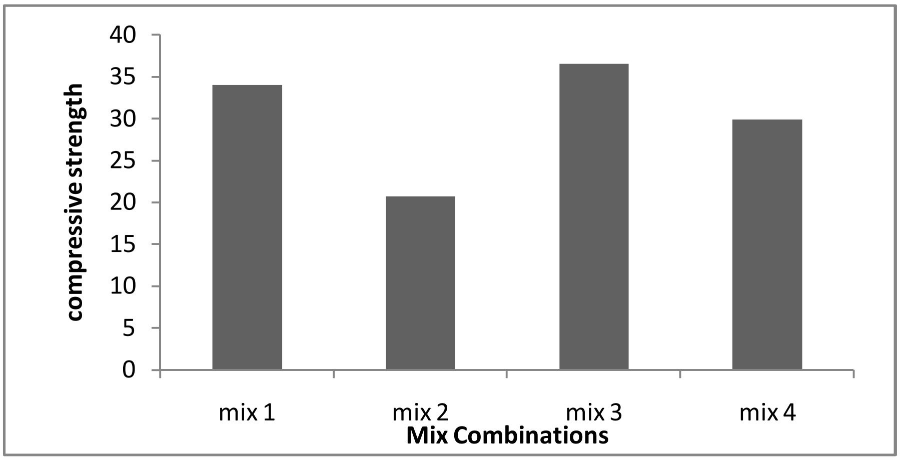

Figure 4 Comparison of 7 day cube compressive strength

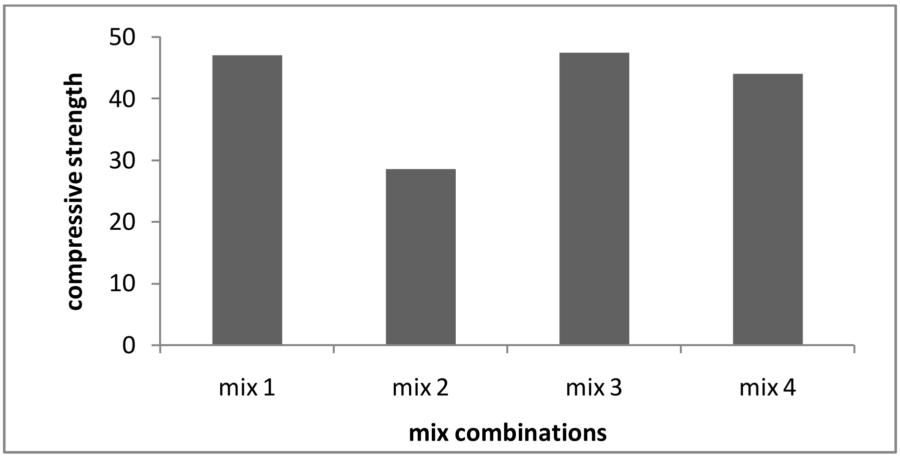

Figure 5 Strength comparison on 28 days compressive strength test on cubes

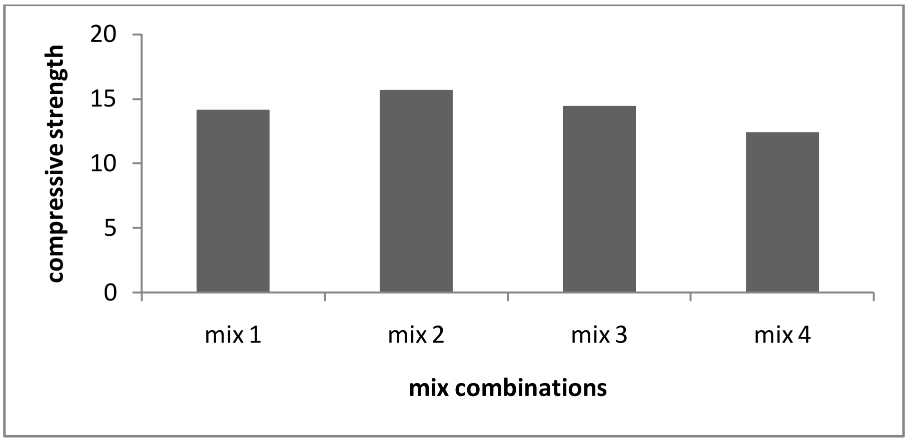

Figure 6 Strength comparison on 28 days compressive strength test on cylinders.

Mix 1 : traditional concrete
Mix 2: fully laterized concrete
Mix 3: concrete replacing ordinary sand with M- sand
Mix 4: concrete replacing ordinary sand with 50% laterite and 50% M- sand.

6. RESULTS AND DISCUSSIONS

The target mean strength assumed for the concrete is 40 N/mm^2. For traditional concrete the compressive strength achieved is 34.04 which is 14.09% less than the target mean strength assumed. When comparing the 28 days compressive strength of the concrete attains 47.11MPa which is 7.11 greater than what assumed. Considering the case of fully laterized concrete the compressive strength achieved at 7 days is 20.71 which is 48.3% less than the target strength assumed. From the studies conducted on using laterite soil as a sole fine aggregate it is found that fully replacing sand with laterite soil reduces the strength of the concrete. While replacing sand with laterite soil it is best to replace partially. On comparing the 28 days compressive strength of fully laterized concrete, the strength achieved is 28.58 . For concrete replacing sand completely with M- sand, the strength achieved on 7th day compressive strength test is 36.58 and the strength achieved on 28th day compressive strength test is 38.08 . Concrete is casted replacing sand with 50% laterite soil and 50% M- sand. The 7days compressive strength achieved is 29.87, which is 25.33 % less than the target mean strength assumed. But when comparing the 28 days compressive strength the concrete achieved a strength of 44.08 which is 10.02% greater than the target strength assumed. The grading curve for strength obtained by each mix combinations in 7, 14 and 28 days are shown in figure 7.

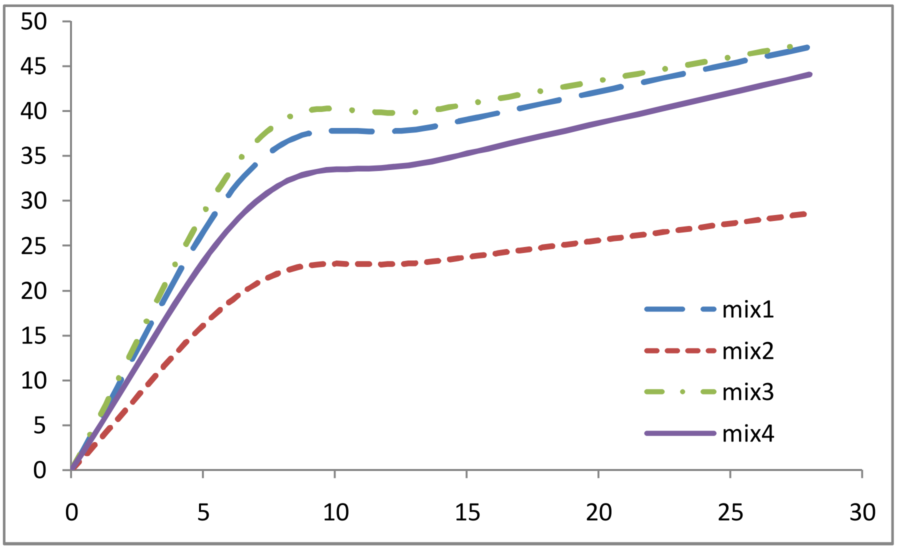

Figure 7 Strength obtained by each mix in 7, 14 and 28 days

7. CONCLUSIONS

From the earlier studied it is found that Laterite soil can be used as a sole fine aggregate in structural concrete. Such laterized concrete can be used in constructing structures or concrete elements under mild circumstances that experience a protection from harsh weather conditions. In this work the ultimate compressive strength obtained by traditional concrete is 47.11 N/mm^2. Comparing fully laterized concrete, the ultimate strength obtained is 28.58N/mm^2 which is 40% less. This is due to the increase in percentage of fine sand in laterite soil. Comparing the case of concrete replacing sand with M- sand, the ultimate

compressive strength is found to be 38.08 which is 20% less than the compressive strength of traditional concrete. when considering concrete made by replacing sand with 50% laterite soil and 50% M- sand, it is found that the ultimate compressive strength is 44.08 N/mm^2, which is greater than the compressive strength of all other mixes and slightly less than the compressive strength of traditional concrete. So we recommend using a combination of laterite soil and manufactured sand commonly called as M- Sand as a replacement for ordinary sand in concrete. Since the laterized concrete has a lower unit weight than the traditional concrete, it would be more suitable with problematic soil that has poor bearing capacities. The abundant availability of Laterite soil throughout the country would greatly contribute towards low cost building and thereby reducing the over exploitation of ordinary sand which is causing a lot of environmental issues today. The resultant burrow pits could be well utilized for sanitary landfills and recovered for other convenient uses.

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